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भारतीय मानक

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भाग 3 अलग-अलग सामग्री की विशिष्टि

Indian Standard

COMBINED FLEXIBLE MATERIALS FOR ELECTRICAL INSULATION

PART 3 SPECIFICATION FOR INDIVIDUAL MATERIALS

ICS 29.035.20 : 83.140.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Solid Electrical Insulating Materials Sectional Committee, ETD 02

NATIONAL FOREWORD

This Indian Standard (Part 3) which is identical with IEC 626-3(1996) 'Combined flexible materials for electrical insulation — Part 3 : Specifications for individual materials' issued by the International Electrotechnical Commission(IEC), was adopted by the Bureau of Indian Standards on the recommendation of the Solid Electrical Insulating Materials Sectional Committee (ETD 02) and approval of the Electrotechnical Division Council.

This standard (Part 3) specifies the dimensional and performance requirements for individual combined flexible materials.

This standard is one of the series of standards which deal with combined flexible materials consisting of two or more different insulating materials laminated together. The components of combined materials are plastic film and/or fibrous materials, such as papers, woven or non-woven fabrics, impregnated or not impregnated. This standard does not include materials based on mica paper, nor does it deal with combined materials in which one of the components is deliberately left in the B-stage.

The series has three parts as follows:

Part 1 Definitions and general requirements
Part 2 Methods of test
Part 3 Specifications for individual materials

Certain conventions appearing in this dual number standard are not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English language text in the IEC standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2:1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in the standard.

Indian Standard

COMBINED FLEXIBLE MATERIALS FOR ELECTRICAL INSULATION

PART 3 SPECIFICATION FOR INDIVIDUAL MATERIALS

1 Scope

This part of IEC 626 specifies dimensional and performance requirements for individual combined flexible materials. This part is in the form of groups of sheets. Sheets are numbered in accordance with table 1, which provides a complete list of all the specification sheets belonging to this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 626. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 626 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. In the event of dispute, the referenced editions shall be used.

IEC 554-1: 1977, *Specification for cellulosic papers for electrical purposes – Part 1: Definitions and general requirements*

IEC 554-3, *Specification for cellulosic papers for electrical purposes – Part 3: Specifications for individual materials*

IEC 626-1: 1995, *Combined flexible materials for electrical insulation – Part 1: Definitions and general requirements*

IEC 626-2: 1995, *Combined flexible materials for electrical insulation – Part 2: Methods of test*

IEC 641-1: 1979, *Specification for pressboard and presspaper for electrical purposes – Part 1: Definitions and general requirements*

IEC 641-3: *Specification for pressboard and presspaper for electrical purposes – Part 3: Specifications for individual materials*

IEC 674-1: 1980, *Specification for plastic films for electrical purposes – Part 1: Definitions and general requirements*

IEC 674-3: *Specification for plastic films for electrical purposes – Part 3: Specifications for individuals materials*

IEC 819-1: 1995, *Non-cellulosic papers for electrical purposes – Part 1: Definitions and general requirements*

IEC 819-3: *Specification for non-cellulosic papers for electrical purposes – Part 3: Specifications for individual materials*

3 Requirements

In addition to complying with the general requirements of IEC 626-1, each flexible combined laminate shall conform to the requirements set forth in the appropriate sheet corresponding to its type, as shown in the sheets of this standard.

4 Designation

Table 1 lists material designations and constructions appropriate to each sheet. Material conforming to this specification shall be identified by a designation containing the IEC standard number, the material designation from IEC 626-1 and the nominal thickness. For example:

IEC 626-3, Sheet 112, P-C/F-PET/P-C, 0,15 mm

5 Thermal classification

Performance experience provides information about the thermal capability of combined flexible materials in electrical insulation systems. This information is given in each individual sheet. Thermal classification information on these sheets is not to be considered as a requirement.

6 Specification sheets

Table 1 – Master listing for IEC 626-3 sheet identification

Sheet No.	Flexible laminate composition
100 to 149	Paper or presspaper containing sulphate woodpulp fibres
100 to 109	Duplex with PET film
110 to 119	Triplex with PET film
120 to 149	Others
150 to 199	Paper or presspaper containing cotton fibres
150 to 159	Duplex with PET film
160 to 169	Triplex with PET film
170 to 199	Others
200 to 249	Paper or presspaper containing both cotton and woodpulp fibres
200 to 209	Duplex with PET film
210 to 219	Triplex with PET film
220 to 249	Others
250 to 299	Paper or presspaper containing other cellulosic fibres or mixtures of cellulosic and non-cellulosic fibres
300 to 399	Wet-laid paper containing organic non-cellulosic fibres
300 to 309	Duplex calendered aramid with PET film
310 to 319	Triplex calendered aramid with PET film
320 to 329	Triplex uncalendered aramid with PET film
330 to 339	Triplex calendered aramid with PI film
340 to 399	Others
400 to 499	Wet-laid paper containing inorganic fibres
400 to 459	Glass
460 to 499	Others
500 to 599	Dry-laid non-woven containing organic fibres
500 to 519	100 % PET-based fibres
520 to 539	100 % aramid-based fibres
540 to 599	Others
600 to 999	Other constructions

NOTE - Not all the specification sheets listed in this table are yet available.

The specification sheets available are given below.

Sheet 100

Requirements for combined flexible duplex materials of two layers – F-PET/P-C (23 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for duplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on a polyethylene terephthalate film (F-PET) having a nominal thickness of 23 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3 or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 23 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 6 kV;
- for folded specimens: 5 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below:

Property	Clause in IEC 626-2	Units Tolerance											
Laminate nominal thickness	2	mm	0,10	0,13	0,15	0,18	0,20	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	10	10	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	115	155	190	215	250	300	370	430	490	610	730
Unfolded tensile strength	4	N/10 mm min. MD	90	100	135	150	180	220	270	300	360	450	540
		CMD	60	70	90	100	120	140	180	200	240	300	360
Folded tensile strength, film inside	4	N/10 mm min. MD	70	80	100	110	140	170	210	240	280	350	420
		CMD	40	50	60	70	80	100	120	140	160	200	240
Elongation, unfolded	4	% min. MD	3	3	3	3	5	5	5	5	5	5	5
		CMD	10	10	10	10	13	13	13	13	13	13	13

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 101

Requirements for combined flexible duplex materials of two layers – F-PET/P-C (36 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for duplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on a polyethylene terephthalate film (F-PET) having a nominal thickness of 36 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 36 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 7 kV;
- for folded specimens: 6 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance										
Laminate nominal thickness	2	mm	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	15	15	10	10	10	10	10	10
Laminate nominal grammage	3	g/m² ±12 %	120	190	250	280	370	395	490	510	610	790
Unfolded tensile strength	4	N/10 mm min.										
		MD	90	135	180	190	270	280	360	380	450	540
		CMD	60	90	120	130	180	190	240	250	300	360
Folded tensile strength, film inside	4	N/10 mm min.										
		MD	70	100	130	150	200	230	270	300	340	410
		CMD	40	60	80	90	120	130	160	170	200	240
Elongation, unfolded	4	% min.										
		MD	3	3	5	5	5	5	5	5	5	5
		CMD	10	10	13	13	13	13	13	13	13	13

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 102

Requirements for combined flexible duplex materials of two layers – F-PET/P-C (50 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for duplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on a polyethylene terephthalate film (F-PET) having a nominal thickness of 50 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 50 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 8 kV;
- for folded specimens: 6 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance									
Laminate nominal thickness	2	mm	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	15	15	10	10	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	190	245	305	360	420	480	535	590	700
Unfolded tensile strength	4	N/10 mm min. MD	100	120	150	190	240	300	360	380	400
		CMD	80	90	95	105	120	150	180	190	200
Folded tensile strength, film inside	4	N/10 mm min. MD	70	80	95	130	180	230	275	300	320
		CMD	40	50	60	90	115	145	175	180	190
Elongation, unfolded	4	% min. MD	3	3	3	3	5	5	5	5	5
		CMD	10	10	10	10	13	13	13	13	13

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 110

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (23 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 23 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 23 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 6 kV;
- for folded specimens: 5 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance										
Laminate nominal thickness	2	mm	0,12	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	10	10	10	10	10	10	10	10
Laminate nominal grammage	3	g/m² ±12 %	140	170	230	270	370	430	490	550	610	730
Unfolded tensile strength	4	N/10 mm min.										
		MD	100	135	160	190	270	300	360	400	450	540
		CMD	70	90	120	130	160	200	240	270	300	360
Folded tensile strength	4	N/10 mm min.										
		MD	60	105	140	150	210	240	260	310	350	420
		CMD	40	60	80	90	120	135	160	175	200	240
Elongation, unfolded	4	% min.										
		MD	3	3	5	5	5	5	5	5	5	5
		CMD	10	10	10	10	10	10	10	10	10	10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 111

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (36 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 36 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 36 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 7 kV;
- for folded specimens: 6 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance										
Laminate nominal thickness	2	mm	0,12	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	15	10	10	10	10	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	150	180	240	300	370	430	490	550	610	730
Unfolded tensile strength	4	N/10 mm min. MD CMD	 100 75	 135 100	 180 120	 200 130	 270 180	 300 200	 360 240	 400 255	 450 300	 540 360
Folded tensile strength	4	N/10 mm min. MD CMD	 85 50	 100 60	 140 80	 160 90	 210 120	 230 130	 280 160	 300 175	 350 200	 420 240
Elongation, unfolded	4	% min. MD CMD	 5 10	 5 10	 5 10	 5 10	 5 10	 5 10	 5 10	 5 10	 5 10	 5 10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 112

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (50 μm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 50 μm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 50 μm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 8 kV;
- for folded specimens: 6 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance								
Laminate nominal thickness	2	mm	0,15	0,25	0,30	0,35	0,40	0,45	0,50	0,55
Laminate thickness tolerance	2	± %	15	15	10	10	10	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	200	320	380	440	490	550	620	700
Unfolded tensile strength	4	N/10 mm min. MD CMD	 135 100	 200 130	 270 180	 310 200	 360 240	 400 255	 450 300	 540 360
Folded tensile strength	4	N/10 mm min. MD CMD	 100 60	 160 80	 210 120	 235 130	 280 160	 300 175	 350 200	 420 240
Elongation, unfolded	4	% min. MD CMD	 3 10	 3 10	 3 10	 3 10	 5 10	 5 10	 5 10	 5 10
NOTES MD = machine direction CMD = cross machine direction min. = minimum										

Sheet 113

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (75 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 75 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 75 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 10 kV;
- for folded specimens: 9 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance									
Laminate nominal thickness	2	mm	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,60
Laminate thickness tolerance	2	± %	15	15	10	10	10	10	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	190	240	310	380	430	510	560	620	740
Unfolded tensile strength	4	N/10 mm min.									
		MD	140	190	230	280	330	380	420	470	570
		CMD	105	140	170	210	240	280	310	350	420
Folded tensile strength	4	N/10 mm min.									
		MD	100	130	160	200	230	270	300	340	410
		CMD	65	90	110	120	130	180	200	220	270
Elongation, unfolded	4	% min.									
		MD	5	5	5	5	5	5	5	5	5
		CMD	10	10	10	10	10	10	10	10	10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 114

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (100 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 100 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 100 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 11 kV;
- for folded specimens: 9 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance				
Laminate nominal thickness	2	mm	0,20	0,30	0,40	0,50
Laminate thickness tolerance	2	± %	15	10	10	10
Laminate nominal grammage	3	g/m² ±12 %	250	380	510	620
Unfolded tensile strength	4	N/10 mm min.				
		MD	200	300	400	500
		CMD	160	240	320	400
Folded tensile strength	4	N/10 mm min.				
		MD	140	210	280	350
		CMD	100	150	200	250
Elongation, unfolded	4	% min.				
		MD	5	5	5	5
		CMD	10	10	10	10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 115

Requirements for combined flexible triplex materials of three layers – P-C/F-PET/P-C (125 µm PET film with presspaper or paper)

1 Description

This sheet gives the requirements for triplex materials consisting of paper or presspaper containing sulphate woodpulp fibres (P-C) laminated on both sides of a polyethylene terephthalate film (F-PET) having a nominal thickness of 125 µm.

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 120 °C to 130 °C.

3 Single-layer requirements

Use paper which meets the requirements for classes 1.1, 1.2, 1.3, or 1.4 of IEC 554-1 and IEC 554-3. Alternatively, use presspaper which meets the requirements for P2 or P4 of IEC 641-1 and IEC 641-3. Each of these presspapers or papers can have a different density, which will affect the nominal grammage of the laminate.

Use a PET film which has a nominal thickness of 125 µm and meets the requirements of IEC 674-1 and IEC 674-3.

4 Breakdown voltage requirements

For all laminates listed in clause 5, the minimum electric breakdown voltage using 6 mm diameter electrodes is:

- for unfolded specimens: 13 kV;
- for folded specimens: 11 kV.

However, in accordance with IEC 626-2, a minimum electric breakdown voltage on folded specimens is not required for laminates of nominal thickness greater than 0,5 mm.

5 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance				
Laminate nominal thickness	2	mm	0,20	0,30	0,40	0,50
Laminate thickness tolerance	2	± %	15	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	260	380	515	635
Unfolded tensile strength	4	N/10 mm min.				
		MD	200	300	400	500
		CMD	160	240	320	400
Folded tensile strength	4	N/10 mm min.				
		MD	140	210	280	350
		CMD	100	150	200	250
Elongation, unfolded	4	% min.				
		MD	5	5	5	5
		CMD	10	10	10	10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 302

Requirements for combined flexible duplex materials of two layers – P-PAa/F-PET (50 μm aramid calendered paper with PET film)

1 Description

This sheet gives the requirements for duplex materials consisting of calendered aramid paper (P-PAa) having a nominal thickness of 50 μm laminated to a polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 130 °C to 155 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance									
Laminate nominal thickness	2	mm	0,08	0,10	0,11	0,13	0,16	0,18	0,25	0,31	0,41
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	15	10	10
Laminate nominal grammage	3	g/m² ±12 %	95	110	125	160	190	230	320	390	550
Film nominal thickness		μm	23	36	50	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min.									
		MD	100	120	130	140	160	180	230	280	340
		CMD	70	80	80	90	100	120	200	300	320
Folded tensile strength, film inside	4	N/10 mm min.									
		MD	60	70	80	90	100	130	150	200	250
		CMD	50	60	60	80	90	100	150	200	250
Elongation, unfolded	4	% min.									
		MD	15	15	15	15	15	15	20	20	20
		CMD	20	20	20	20	20	20	20	20	20
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min.									
		Unfolded	5	6	7	9	10	12	15	18	21
		Folded	4	5	6	8	8	10	12	15	18

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 303

Requirements for combined flexible duplex materials of two layers – P-PAa/F-PET (80 μm aramid calendered paper with PET film)

1 Description

This sheet gives the requirements for duplex materials consisting of calendered aramid paper (P-PAa) having a nominal thickness of 80 μm laminated to a polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 130 °C to 155 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance									
Laminate nominal thickness	2	mm	0,11	0,12	0,14	0,16	0,19	0,22	0,28	0,34	0,44
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	15	10	10
Laminate nominal grammage	3	g/m² ±12 %	120	135	155	190	220	255	340	420	565
Film nominal thickness		μm	23	36	50	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min. MD	100	120	130	140	160	180	230	280	340
		CMD	70	80	80	90	100	120	200	300	320
Folded tensile strength, film inside	4	N/10 mm min. MD	60	70	80	90	100	130	150	200	250
		CMD	50	60	60	80	90	100	150	200	250
Elongation, unfolded	4	% min. MD	15	15	15	15	15	15	20	20	20
		CMD	20	20	20	20	20	20	25	25	25
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded	6	7	8	10	11	13	16	18	21
		Folded	5	6	6	8	9	11	13	15	18

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 312

Requirements for combined flexible triplex materials of three layers – P-PAa/F-PET/P-PAa (50 µm aramid calendered paper on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of calendered aramid paper (P-PAa) having a nominal thickness of 50 µm laminated on both sides of polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 155 °C to 180 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance									
Laminate nominal thickness	2	mm	0,14	0,15	0,17	0,19	0,22	0,24	0,31	0,37	0,47
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	15	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	140	150	170	200	230	270	360	450	590
Film nominal thickness		µm	23	36	50	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min. MD CMD	100 80	150 90	160 90	170 105	190 120	220 150	270 200	330 300	400 350
Folded tensile strength	4	N/10 mm min. MD CMD	80 50	80 70	90 70	100 90	110 100	130 120	200 150	250 200	300 250
Elongation, unfolded	4	% min. MD CMD	15 20	15 20	15 20	15 20	15 20	20 20	20 25	20 25	20 25
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	6 5	7 6	8 7	11 9	12 10	14 12	19 15	23 18	28 20

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 313

Requirements for combined flexible triplex materials of three layers – P-PAa/F-PET/P-PAa (80 μm aramid calendered paper on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of calendered aramid paper (P-PAa) having a nominal thickness of 80 μm laminated on both sides of polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 155 °C to 180 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance										
Laminate nominal thickness	2	mm	0,20	0,21	0,22	0,25	0,28	0,30	0,36	0,43	0,48	0,53
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	15	10	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	185	200	220	255	290	325	420	500	570	640
Film nominal thickness		μm	23	36	50	75	100	125	190	250	350	350
Unfolded tensile strength	4	N/10 mm min. MD CMD	 160 100	 160 120	 170 140	 190 180	 220 190	 270 200	 320 250	 380 300	 430 300	 450 300
Folded tensile strength	4	N/10 mm min. MD CMD	 80 60	 90 70	 160 100	 180 140	 190 150	 200 160	 250 200	 300 250	 300 250	 300 250
Elongation, unfolded	4	% min. MD CMD	 15 20	 15 20	 15 20	 15 20	 15 20	 20 25	 20 25	 20 25	 20 25	 20 25
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	 7 5	 8 7	 9 8	 12 10	 13 11	 15 13	 20 16	 23 18	 25 20	 30 NR

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum
NR = no requirement

Sheet 315

Requirements for combined flexible triplex materials of three layers – P-PAa/F-PET/P-PAa (130 µm aramid calendered paper on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of calendered aramid paper (P-PAa) having a nominal thickness of 130 µm laminated on both sides of polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 155 °C to 180 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	*Clause in* IEC 626-2	*Units* Tolerance					
Laminate nominal thickness	2	mm	0,32	0,35	0,37	0,40	0,52
Laminate thickness tolerance	2	± %	15	15	15	15	15
Laminate nominal grammage	3	g/m² ±12 %	330	360	400	440	620
Film nominal thickness		µm	50	75	100	125	250
Unfolded tensile strength	4	N/10 mm min.					
		MD	200	220	250	300	400
		CMD	170	200	220	260	320
Folded tensile strength	4	N/10 mm min.					
		MD	170	190	210	230	330
		CMD	120	130	150	190	300
Elongation, unfolded	4	% min.					
		MD	7	7	7	7	15
		CMD	10	10	10	10	20
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min.					
		Unfolded	10	13	14	16	25
		Folded	8	11	12	14	NR

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum
NR = no requirement

Sheet 320

Requirements for combined flexible triplex materials of three layers – P-PAa/F-PET/P-PAa (130 µm aramid uncalendered paper on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of uncalendered aramid paper (P-PAa) having a nominal thickness of 130 µm laminated on both sides of polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 155 °C to 180 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance						
Laminate nominal thickness	2	mm	0,28	0,30	0,32	0,35	0,37	0,40
Laminate thickness tolerance	2	± %	20	20	20	20	20	20
Laminate nominal grammage	3	g/m^2 ±12 %	135	155	170	205	240	280
Film nominal thickness		µm	23	36	50	75	100	125
Unfolded tensile strength	4	N/10 mm min.						
		MD	45	60	75	100	120	140
		CMD	45	60	75	100	120	140
Folded tensile strength	4	N/10 mm min.						
		MD	40	50	75	80	100	120
		CMD	40	50	75	80	100	120
Elongation, unfolded	4	% min.						
		MD	7	7	7	7	7	7
		CMD	10	10	10	10	10	10
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min.						
		Unfolded	4	5	6	9	10	12
		Folded	3	4	5	6	9	10

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 330

Requirements for combined flexible triplex materials of three layers – P-PAa/F-PI/P-PAa (aramid calendered paper on both sides of PI film)

1 Description

This sheet gives the requirements for triplex materials consisting of calendered aramid paper (P-PAa) laminated on both sides of polyimide film (F-PI).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 180 °C to 200 °C.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PI film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance						
Laminate nominal thickness	2	mm	0,14	0,17	0,20	0,22	0,30	0,32
Laminate thickness tolerance	2	± %	15	15	15	15	15	15
Laminate nominal grammage	3	g/m^2 ±12 %	135	170	190	220	300	330
Film nominal thickness		µm	25	50	25	50	25	50
Aramid paper nominal thickness		µm	50	50	80	80	130	130
Unfolded tensile strength	4	N/10 mm min. MD CMD	 140 80	 160 90	 160 100	 200 180	 270 150	 300 260
Folded tensile strength	4	N/10 mm min. MD CMD	 70 50	 90 70	 80 60	 160 100	 140 90	 180 130
Elongation, unfolded	4	% min. MD CMD	 15 15	 17 17	 15 15	 17 17	 15 15	 17 17
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	 7 6	 9 8	 7 6	 9 8	 7 6	 9 8

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 502

Requirements for combined flexible triplex materials of three layers – P-PET/F-PET/P-PET (50 µm PET mat on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of a dry-laid non-woven mat made from PET fibre (P-PET) having a nominal thickness of 50 µm laminated on both sides of polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 130 °C to 155 °C. The upper limit can be applied to those laminates which contain mats impregnated with resins that allow the laminate to retain adequate electrical insulation properties at elevated temperatures.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance								
Laminate nominal thickness	2	mm	0,13	0,15	0,18	0,20	0,23	0,30	0,35	0,45
Laminate thickness tolerance	2	± %	15	15	15	15	15	15	10	10
Laminate nominal grammage	3	g/m^2 ±12 %	115	145	190	220	260	350	425	560
Film nominal thickness		µm	23	50	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min. MD CMD	 50 40	 110 90	 140 105	 160 120	 200 150	 300 200	 350 300	 400 350
Folded tensile strength	4	N/10 mm min. MD CMD	 35 30	 90 70	 105 90	 120 100	 150 120	 200 150	 300 200	 350 250
Elongation, unfolded	4	% min. MD CMD	 20 50	 20 50	 20 50	 20 50	 20 50	 20 50	 20 50	 20 50
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	 4 3	 6 5	 7 6	 9 8	 10 9	 15 13	 18 16	 22 20

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 503

Requirements for combined flexible triplex materials of three layers – P-PET/F-PET/P-PET (75 µm PET mat on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of a dry-laid non-woven mat made from PET fibre (P-PET) having a nominal thickness of 75 µm laminated on both sides of a polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 130 °C to 155 °C. The upper limit can be applied to those laminates which contain mats impregnated with resins that allow the laminate to retain adequate electrical insulation properties at elevated temperatures.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance						
Laminate nominal thickness	2	mm	0,23	0,25	0,28	0,34	0,40	0,50
Laminate thickness tolerance	2	± %	20	20	20	20	20	20
Laminate nominal grammage	3	g/m^2 ±12 %	230	265	300	390	480	620
Film nominal thickness		µm	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min. MD CMD	 140 105	 180 120	 220 150	 270 200	 300 300	 340 300
Folded tensile strength	4	N/10 mm min. MD CMD	 100 90	 120 100	 150 120	 200 150	 300 200	 300 200
Elongation, unfolded	4	% min. MD CMD	 20 40	 20 40	 20 40	 20 40	 20 40	 20 40
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	 7 6	 9 8	 10 9	 15 13	 18 16	 22 20

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum

Sheet 505

Requirements for combined flexible triplex materials of three layers – P-PET/F-PET/P-PET (125 µm PET mat on both sides of PET film)

1 Description

This sheet gives the requirements for triplex materials consisting of a dry-laid non-woven mat made from PET fibre (P-PET) having a nominal thickness of 125 µm laminated on both sides of a polyethylene terephthalate film (F-PET).

2 Thermal classification

Experience has shown that the combined flexible materials listed in this sheet may be suitable for use in electrical apparatus with ratings up to and including the range of 130 °C to 155 °C. The upper limit can be applied to those laminates which contain mats impregnated with resins that allow the laminate to retain adequate electrical insulation properties at elevated temperatures.

3 Single-layer requirements

Use paper which meets the requirements of IEC 819-1 and IEC 819-3.

Use a PET film which meets the requirements of IEC 674-1 and IEC 674-3.

4 Additional requirements

Additional requirements are given in the table below.

Property	Clause in IEC 626-2	Units Tolerance						
Laminate nominal thickness	2	mm	0,31	0,34	0,36	0,42	0,48	0,58
Laminate thickness tolerance	2	± %	20	20	20	20	20	20
Grammage nominal grammage	3	g/m^2 ±12 %	290	330	360	450	530	650
Unfolded tensile strength		µm	75	100	125	190	250	350
Unfolded tensile strength	4	N/10 mm min. MD CMD	 180 105	 200 120	 240 150	 300 200	 340 300	 400 350
Folded tensile strength	4	N/10 mm min. MD CMD	 100 90	 120 100	 150 120	 200 150	 300 200	 350 . 250
Elongation, unfolded	4	% min. MD CMD	 20 40	 20 40	 20 40	 20 40	 20 40	 20 40
Electric breakdown voltage, 6 mm diameter electrodes	9	kV min. Unfolded Folded	 7 6	 9 8	 10 9	 15 13	 18 16	 22 NR

NOTES
MD = machine direction
CMD = cross machine direction
min. = minimum
NR = no requirement

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